

example scenarios in the Science and Engineering Report (DIRS 153849-DOE 2001, Section 2.1.5). As stated in the Science and Engineering Report, for the higher-temperature repository operating mode, the start of closure could occur as early as 50 years after initial emplacement. The EIS analysis of the higher-temperature operating mode assumes that closure would begin 100 years after the start (76 years after the completion) of emplacement to facilitate comparisons. The lower-temperature repository operating mode would require a longer period of ventilation. This EIS evaluates closure of the repository in the lower-temperature mode after forced ventilation for as many as 324 years after the start of emplacement.

The performance confirmation program would continue some of the activities initiated during site characterization until repository closure, including various types of tests, experiments, and analytical procedures. DOE would conduct performance confirmation activities to further evaluate the accuracy and adequacy of the information used to demonstrate compliance that the repository would meet performance objectives.

Throughout the construction, operation, monitoring and maintenance, and closure periods, the repository would remain under effective institutional control. Under institutional control, the repository would be maintained to ensure that workers and the public were protected adequately in compliance with applicable Federal regulations and the requirements in DOE Order 5400.5 “Radiation Protection of the Public and the Environment.”

Repository closure would occur after DOE received a license amendment from the Nuclear Regulatory Commission. Closure would take about 10 years for the higher-temperature repository operating mode (DIRS 150941-CRWMS M&O 2000, p. 6-22), and from 11 to 17 years for the lower-temperature repository operating mode. Closure of the repository facilities would include emplacing the drip shields, closing the subsurface facilities, completely decontaminating and decommissioning the surface facilities, reclaiming the disturbed surface areas, and establishing long-term institutional controls, including land records and warning systems to limit or prevent intentional or unintentional activity in and around the closed repository. DOE would establish a postclosure monitoring program, as required by Section 801(c) of the Energy Policy Act of 1992 (Public Law 102-486, 106 Stat. 2776); the Nuclear Regulatory Commission has regulations (10 CFR Part 63) addressing postclosure monitoring.

2.1.2.1 Repository Surface Facilities and Operations

Surface facilities at the repository site would receive, prepare, stage, and package spent nuclear fuel and high-level radioactive waste for subsurface emplacement. In addition, they would support the construction of the subsurface facilities. DOE would upgrade some surface facilities built for site characterization, but most would be new. Most facilities would be in three areas—the North Portal Operations Area, the South Portal Development Area, and the Ventilation Shaft Operations Areas. Facilities to support waste emplacement would be concentrated near the North Portal, and facilities to support subsurface facility development would be concentrated near the South Portal. The following sections describe these areas in more detail. In addition, Section 2.1.2.1.4 describes support facilities and utilities.

2.1.2.1.1 North Portal Operations Area

This area, shown in Figure 2-10, would be the largest of the primary operations areas, covering about 0.6 square kilometer (150 acres) (DIRS 104508-CRWMS M&O 1999, Section 4.2.3.1) at the North Portal. It would include two areas: a *Radiologically Controlled Area* for receipt, handling, and packaging of spent nuclear fuel and high-level radioactive waste prior to emplacement, and a Balance of Plant Area for support services (such as administration, training, and maintenance). The Radiologically Controlled Area would be monitored to ensure adequate safeguards and security for radioactive materials. The two

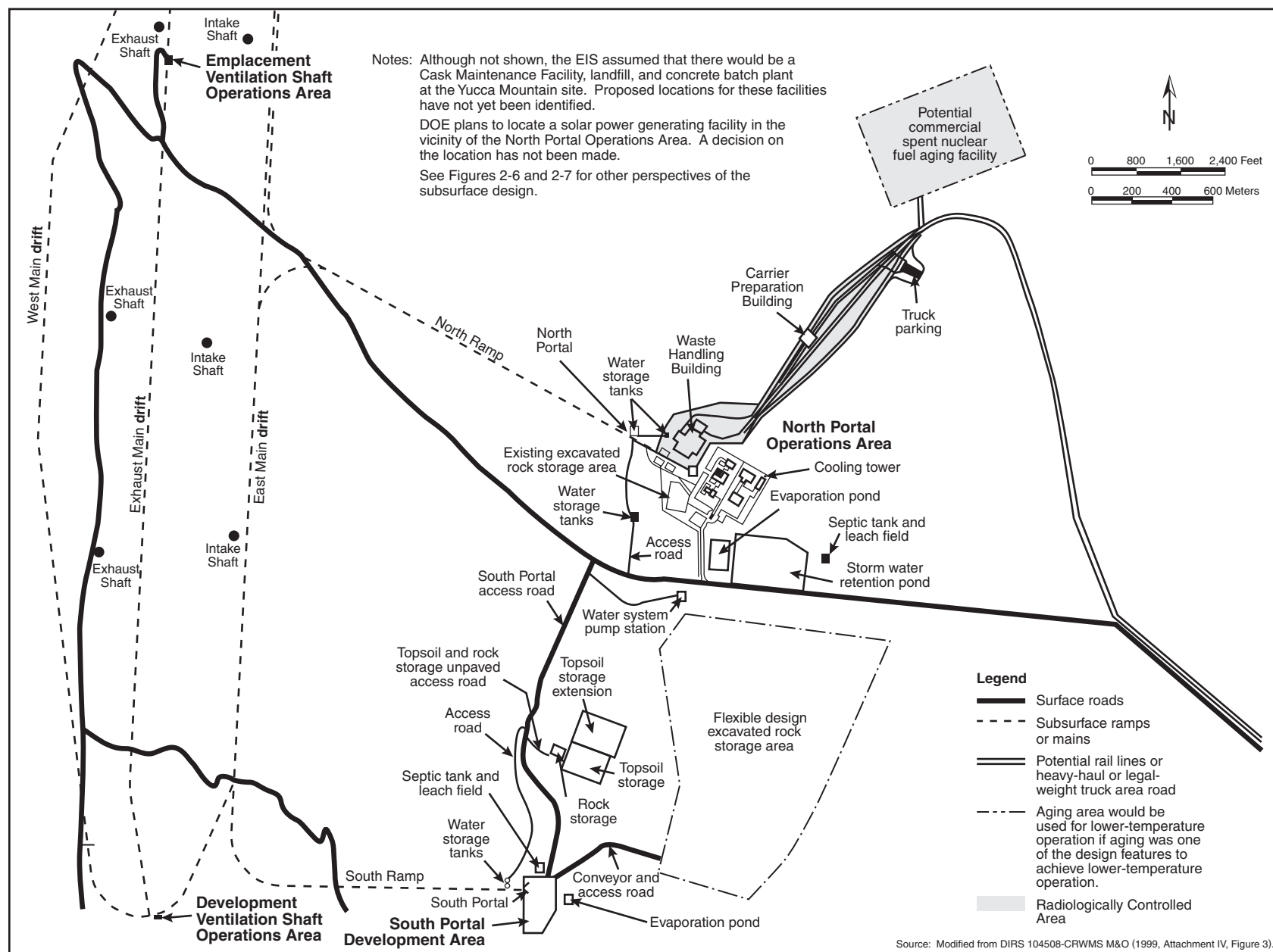


Figure 2-10. Potential repository surface facilities site plan.

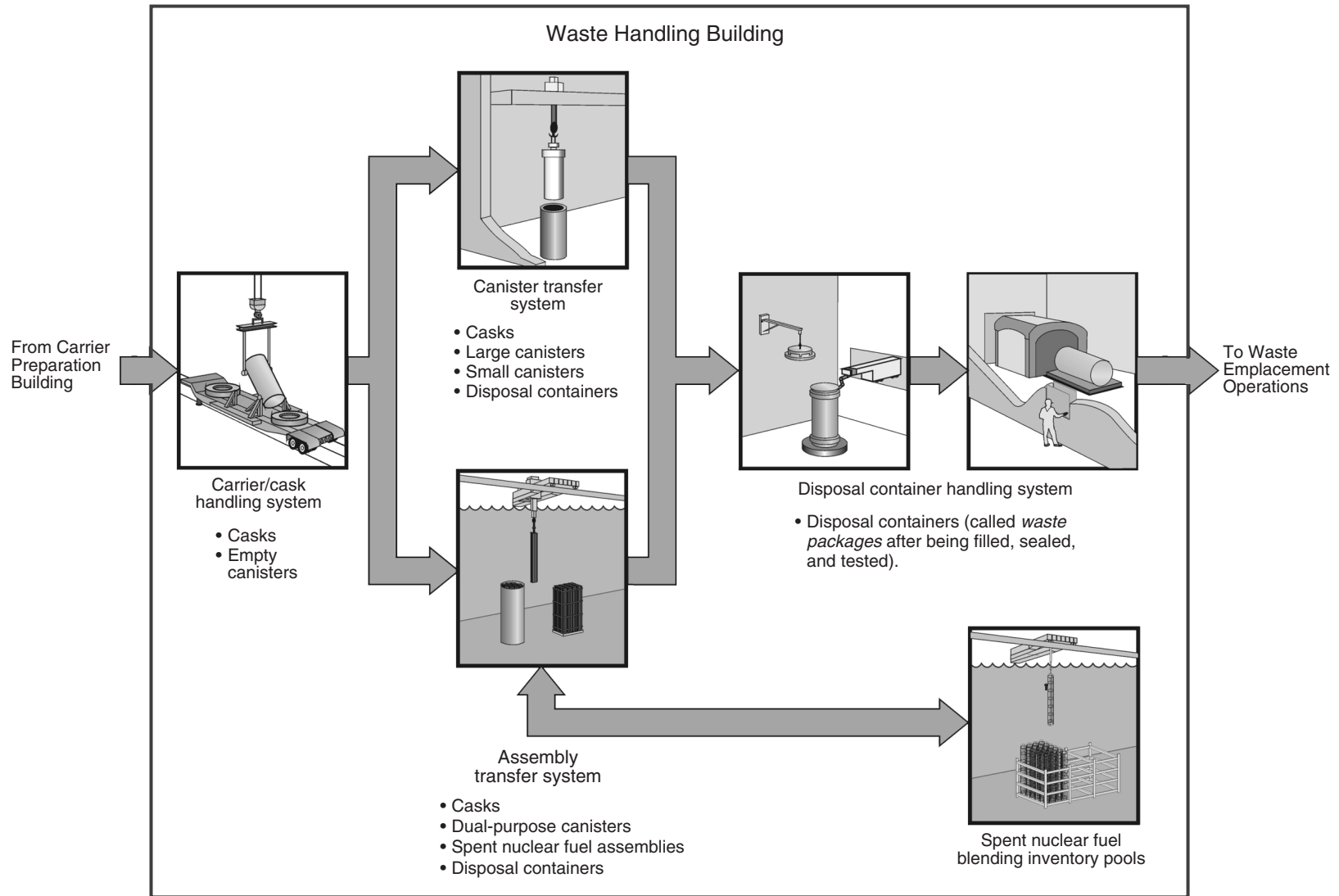
principal facilities in the Radiologically Controlled Area for handling spent nuclear fuel and high-level radioactive waste would be the Carrier Preparation Building and the Waste Handling Building. If DOE uses aging to achieve lower-temperature operation, the commercial nuclear fuel aging area would also be included within the Radiologically Controlled Area. Other support facilities in the North Portal Operations Area would include basic facilities for personnel support, warehousing, security, parking and visitors center, and transportation (motor pool). A concrete plant for fabricating and curing precast components and supplying concrete for *in-situ* placement would be near the North Portal Operations Area.

2.1.2.1.1 Waste Handling. When a legal-weight or heavy-haul truck or a railcar (depending on the transportation mode) hauling a *cask* containing spent nuclear fuel or high-level radioactive waste arrived at the repository site, it would move through the security check into the Radiologically Controlled Area parking area or to the Carrier Preparation Building. Operations in the Carrier Preparation Building would include performing inspections of the vehicle and cask, removing barriers from the vehicle that protected personnel during shipment, and removing *impact limiters* from the cask. The vehicle would then move to the Waste Handling Building for unloading.

At the Waste Handling Building carrier bay, the carrier/cask handling system would lift the transportation cask to a vertical position and place it on a cask transfer cart. Depending on the cask's contents, the cart would move to one of two transfer systems. Casks that contain disposable canisters (for example, DOE canisters that would not be opened but transferred, as is, directly into a *disposal container*) would go to the canister transfer system. Casks that contain commercial spent nuclear fuel in dual-purpose canisters or individual *fuel assemblies* would go to the assembly transfer system. Figure 2-11 is a flow diagram of Waste Handling Building operations.

The Waste Handling Building would have one canister transfer line that moves the disposable canisters through the building to prepare the waste for emplacement in the repository. The system would move arriving casks through an *air lock* on a transfer cart into a cask preparation area. Once a cask arrived inside the cask preparation area, workers would use remotely operated equipment to vent and sample gases from the cask, remove the lid bolts, and open the cask. An overhead crane would move the cask to a transfer cart, which would take the cask to a shielded transfer area. Inside the transfer area, machines would remove the canister from the cask. The canister could go directly into a disposal container for repository emplacement, or to a holding rack for later placement in a disposal container. Another transfer cart would move loaded disposal containers to the disposal container handling system. A transfer cart would move the empty transportation casks back to the cask *decontamination* area, where they would be surveyed and decontaminated, if required, before return shipment. From the decontamination area, casks would be moved to the carrier/cask handling system, which would place them back on a transporter. The empty cask and cask transporter would return to the Carrier Preparation Building to be readied for offsite shipment.

The Waste Handling Building would also have two assembly transfer lines. Each line would operate independently to handle waste throughput and support maintenance operations. The assembly transfer process would begin by moving the cask on a transfer cart through the air lock into the cask preparation area. Once inside the cask preparation area, workers would use remotely operated equipment to inspect, vent, and cool the cask and remove the cask lid bolts. A large overhead crane would lift the casks and place them in a cask unloading pool, where fuel-handling machines would open the casks and unload the fuel assemblies. If the cask contained dual-purpose canisters, they would be removed and placed in an overpack, where the top of the canister would be cut off. The system would move the empty casks and dual-purpose containers back out through the cask decontamination area. The fuel-handling machines would transfer the fuel assemblies, one at a time, to a holding pool, where they would be placed in assembly baskets. A transfer cart would move the baskets containing the fuel assemblies underwater from the assembly holding pool through a transfer canal to a fuel-blending inventory pool. (See



Drawing not to scale.

Source: DIRS 153849-DOE (2001, Figure 2-19).

Figure 2-11. Key components of Waste Handling Building operations.

Section 2.1.2.1.1.2 for further information on the processes for blending, use of small waste packages, and aging to meet the flexible design linear thermal load criteria.) When a fuel assembly was selected from the fuel inventory pool for packaging, a transfer cart would move it underwater back through the fuel blending pool to an inclined transfer canal and onto a cart that connects to the assembly drying area.

After fuel assemblies arrived at the assembly drying area, a fuel-handling machine would transfer them into one of two drying vessels. After drying, the system would retrieve the assemblies and transfer them, one at a time, to a disposal container. The empty assembly baskets would be returned to the pool area for reuse. After installation of the sealing device and the inner lid, the system would then evacuate the disposal container internal cavity and fill it with nitrogen gas to exclude oxygen and prevent corrosion from the inside of the waste package. Finally, the transfer cart would transfer the container to the lid welding and inspection area.

The disposal container handling system would receive loaded disposal containers from both the canister transfer system and the assembly transfer system. Each disposal container would again be evacuated and filled with helium, after which the container's lids would be welded and the welds inspected. If the welds meet inspection criteria, the sealed disposal container would be reclassified as a waste package. A crane would transfer the waste package to the transporter loading area, where it would be decontaminated and placed on a pallet, then on a transporter for emplacement in the subsurface repository.

For more details on waste handling, see Section 2.2.4.2 of the Science and Engineering Report (DIRS 153849-DOE 2001).

2.1.2.1.1.2 Approach to Fuel Blending. Spent nuclear fuel and high-level radioactive waste arriving at the repository would be in solid form, but in a variety of types and sizes. Hence, the materials would arrive in a variety of transportation casks, all certified for use by the Nuclear Regulatory Commission. Commercial spent nuclear fuel would arrive as either individual fuel assemblies placed directly into transportation casks, or in dual-purpose canisters in transportation casks that would have to be opened to remove the fuel assemblies. DOE spent nuclear fuel and high-level radioactive waste would arrive in disposable canisters (that is, canisters that would not be opened, but would be transferred directly into a disposal container). Because of the variety of waste forms to be disposed of, about 10 different designs for disposal containers (called waste packages after being loaded, sealed, and certified) would be needed (DIRS 153849-DOE 2001, Section 2.2.1).

The radioactive decay process generates heat. The concentrations of particular isotopes would vary among the different waste forms, and among different fuel assemblies in the same type of waste form, so different waste packages would generate different amounts of heat. Because the repository would have established temperature limits, DOE would establish a maximum heat output for all waste packages. For the repository, the maximum heat output would be 11.8 kilowatts per waste package (DIRS 153849-DOE 2001, Section 2.2.1).

The limit on heat output from individual waste packages would impose special considerations for operations and costs. The DOE strategy for controlling heat output would be to load waste packages that mixed low-heat-output spent nuclear fuel with high-heat-output spent nuclear fuel to balance total waste package heat output. This process, called *fuel blending* (DIRS 153849-DOE 2001, Section 2.2.1), would apply only to commercial spent nuclear fuel, which generates much more heat than DOE spent nuclear fuel or high-level radioactive waste (see Appendix A).

To manage heat output, DOE would hold some fuel assemblies in the fuel blending pool in the Waste Handling Building inventory until they generated less heat from radioactive decay or until additional low-heat-output fuel assemblies arrived for blending. The repository would be designed with a fuel blending inventory capacity of approximately 5,000 MTHM, or 12,000 spent nuclear fuel assemblies. By

carefully planning and implementing a fuel-blending procedure, DOE could limit and optimize the heat output of the waste packages without increasing their number (DIRS 153849-DOE 2001, Section 2.2.1).

Potential Additional Assembly Transfer Lines in Waste Handling Building. If DOE were to use the smaller waste packages to achieve lower-temperature operation, there would be an increase in the number of assembly transfer lines from two to four. The number of associated hot cells, welding stations, and waste package transporter loading lines would also increase to accommodate the additional canister and waste package handling capacity needed to maintain an emplacement rate of 3,000 MTHM per year. The overall handling process would be the same as that described above.

Potential Commercial Spent Nuclear Fuel Aging Facility. If DOE were to use aging of commercial spent nuclear fuel to achieve the lower-temperature repository operating mode, the aging area would be north and east of the North Portal Operations Area (see Figure 2-10). The spent nuclear fuel aging facility would include access roads, aisles, security fences, and concrete pads to implement the aging process. This area and access to it from the Waste Handling Building would be appropriately restricted for radiation control.

With the use of aging, the handling of commercial spent nuclear fuel would be different than the approach described above because the 5,000-MTHM (12,000 assemblies) blending inventory pools would be unnecessary. Instead, DOE would use a small staging pool for fewer than 80 assemblies for handling processes that required a pool. DOE would replace the assembly transfer system with two dry handling lines, and would add a dry staging hot cell. Commercial spent nuclear fuel would be handled as described above, except it would be loaded into a canister at the surface facility. The canister would be loaded into a dry *storage cask* for movement to and placement on a pad in the aging facility for the duration of the aging period (emplacement with aging is assumed to require 50 years). A motorized or towed transporter, designed to support the aging process, would be used to move the dry storage canister to the aging facility. When the spent nuclear fuel had completed the aging process, it would be transferred from the aging facility to the Waste Handling Building to be placed in a waste package for emplacement as described above.

The Science and Engineering Report (DIRS 153849-DOE 2001), Section 2.1.5, Assessing the Performance of a Lower-Temperature Operating Mode, and Section 2.2, Repository Surface Facilities, provide further detail on the proposed repository higher- and lower-temperature operations. Section 2.2.1 of the Science and Engineering Report provides further discussion on fuel blending strategies and Section 2.2.2.2 provides a more detailed description of the waste handling operations and blending. The essential features for EIS analysis have been presented here.

2.1.2.1.1.3 Generation of Wastes. DOE would decontaminate empty canisters, shipping casks, and related components as required in the Waste Handling Building. After decontamination, the empty canisters and shipping casks would be loaded on truck or rail carriers, sent to the Carrier Preparation Building for processing, and shipped off the site.

Waste generated at the repository from the decontamination of canisters and shipping casks and from other repository housekeeping activities would be collected, processed, packaged, and staged in the Waste Treatment Building before being shipped off the site for disposal at permitted facilities. Waste minimization and pollution prevention measures would reduce the amount of *site-generated waste* requiring such management. For example, decontamination water could be treated and recycled to the extent practicable. Site-generated wastes would include low-level radioactive waste, *hazardous waste*, and *industrial solid waste*. Operations would not be likely, but that could occur, could produce small amounts of mixed wastes (wastes containing both radioactive and hazardous materials). The repository design would include provisions for collecting and storing mixed waste for offsite disposal.

The ventilation systems for the Waste Handling Building and the Waste Treatment Building would provide confinement of radioactive contamination by using pressure differentials to ensure that the air would flow from areas free of contamination to areas potentially contaminated to areas that are normally contaminated. The monitored exhaust air from both buildings would pass through high-efficiency particulate air filters before being released through a single exhaust stack.

2.1.2.1.2 South Portal Development Area

The South Portal Development Area would cover about 0.15 square kilometer (37 acres) immediately adjacent to the South Portal of the subsurface facility. The structures and equipment in this area, which would support the development of subsurface facilities, would include steel warehousing, and basic facilities for personnel support, maintenance, warehousing, material staging, security, and transportation. From this area, overland conveyors would transport excavated rock from the repository to the excavated rock storage area (see Figure 2-10).

2.1.2.1.3 Ventilation Shaft Operations Areas

The higher-temperature repository operating mode would require three emplacement intake *shafts* and one development intake shaft to support simultaneous development and emplacement activities (see Figure 2-12). Three exhaust shafts would support the full emplacement of 70,000 MTHM. The lower-temperature repository operating mode could require three to seven emplacement intake shafts, one development intake shaft, and five to nine exhaust shafts, depending on the repository layout (DIRS 152003-McKenzie 2000, Option 1, p. 3, and Option 2, p. 3). See Section 2.1.2.2.2 for more discussion of the overall ventilation of the repository and Table 2-2 for a comparative listing.

The Ventilation Shaft Operations Area would have separately developed areas of approximately 0.012 square kilometer (3 acres) each for the emplacement intake, development intake, and exhaust shafts. The total area required for ventilation shafts would range from 0.0085 square kilometer (21 acres) for the higher-temperature operating mode and 0.021 square kilometer (51 acres) for the larger lower-temperature operating mode repository. Each exhaust shaft would contain two 2,000-horsepower fans, with a combined capacity of 800 to 850 cubic meters per second (28,000 to 30,000 cubic feet per second). The ventilation system would be monitored for radioactivity and the air would be filtered as needed.

2.1.2.1.4 Support Facilities and Utilities

2.1.2.1.4.1 Storage of Excavated Rock. Repository support facilities and utilities would be on the surface in the general vicinity of the North Portal Operations Area and the South Portal Development Area (see Figure 2-10). The storage area for excavated rock would be the largest support area. The excavated rock storage area for the higher-temperature repository operating mode would be 0.9 square kilometer (220 acres) (DIRS 150941-CRWMS M&O 2000, Figure 6-1). The amount of excavated rock would increase under the lower-temperature repository operating mode as a result of increased waste package spacing. This rock would be stored in the excavated rock storage area, which could be as large as 1.4 square kilometers (347 acres) (DIRS 152003-McKenzie 2000, Option 1, p. 24). Table 2-2 lists the range of the amount of excavated rock for the repository operating modes considered in this Final EIS.

2.1.2.1.4.2 Wastewater and Stormwater Facilities. The repository site would have two evaporation ponds for industrial wastewater, one near the North Portal and one near the South Portal. Sources of industrial wastewater that would go into these ponds include dust suppression water returned to the surface from tunnel boring operations, blowdown from cooling-tower operations at the North Portal, and water from concrete mixing and cleanup. The industrial wastes would be normal operational effluents that would not contain radiological waste and would be processed according to industrial standards and regulations. In both ponds, heavy plastic liners would prevent water migration into the soil.

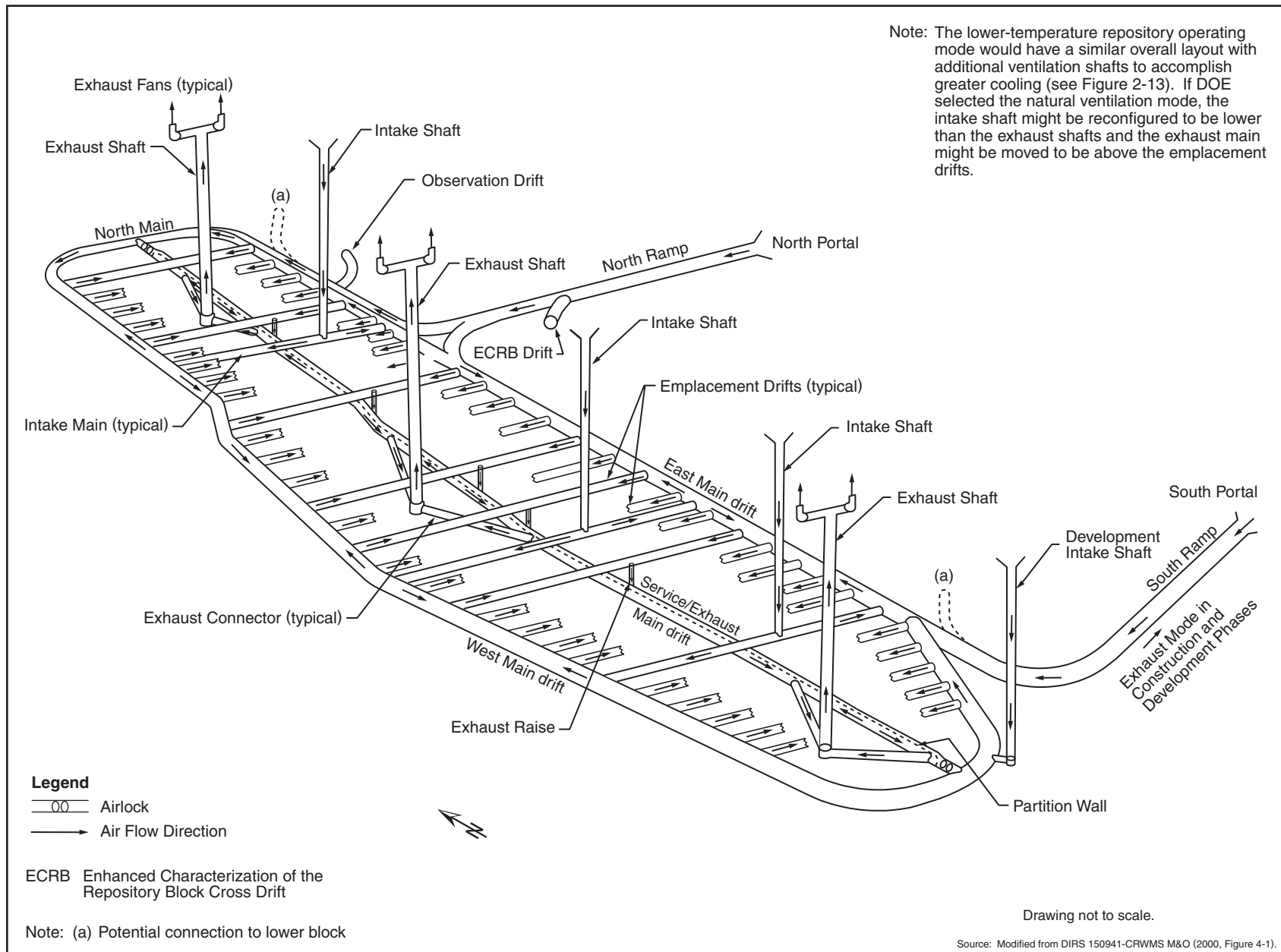


Figure 2-12. Higher-temperature repository operating mode preclosure ventilation air flow in primary block.

The North Portal pond would cover about 0.024 square kilometer (6 acres). The evaporation pond at the South Portal would be about 0.0024 square kilometer (0.6 acre). The North Portal Operations Area would also include an approximately 0.13-square-kilometer (32-acre) stormwater retention pond to control stormwater runoff from the area.

2.1.2.1.4.3 Solid Waste Disposal and Hazardous Waste Management. DOE would package hazardous waste and ship it off the site for treatment and disposal. The Department would develop an appropriately sized landfill [approximately 0.036 square kilometer (9 acres)] at the repository site for nonhazardous and nonradiological construction and *sanitary solid waste* and for similar waste generated during the operation and monitoring and closure phases. The South Portal Development Area would have a septic tank and leach field for the disposal of sanitary sewage. The North Portal Operations Area has an existing septic system that would be adequate for use during repository operations.

2.1.2.1.4.4 Electric Power. The repository would use the Nevada Test Site electric power distribution system, which would require upgrades to handle the demand for the various operational modes considered. At present, electric power at the Yucca Mountain site comes from that system. For the repository, electric power would be distributed throughout the surface and subsurface areas and to remote areas such as the Ventilation Shaft Operations Areas, construction areas, *environmental monitoring* stations, transportation lighting and safety systems, and water wells. To accommodate the expected electric power demand for the repository (estimated to be between 40 and 54 megawatts at peak demand), DOE would upgrade existing electrical transmission and distribution systems. Backup equipment and uninterruptible electric power would ensure personnel safety and operations requiring electric power continuity. Diesel generators and associated switchgear would provide the backup power capability.

In addition, DOE would use electricity from renewable energy sources at the repository (DIRS 153882-Griffith 2001, all). The repository design would include a solar power generating facility, which could produce as much as 3 megawatts of power, and would be a dual-purpose facility, serving as a demonstration of *photovoltaic* power generation and augmenting the overall repository electric power supply (as much as 7 percent). This facility would require about 0.16 square kilometer (40 acres), plus land for an access road and transmission line (DIRS 153882-Griffith 2001, p. 1). The system would be constructed in phases of 500 kilowatts starting in 2005 (DIRS 153882-Griffith 2001, pp. 1 and 6). It would be connected to the repository electric power distribution system. A typical solar power generating facility consists of solar cells (photovoltaic arrays) and support facilities. The solar power generating facility could be in the vicinity of the North Portal Operations Area.

2.1.2.1.4.5 Water Supply. DOE would continue to use existing wells about 5.6 kilometers (3.5 miles) southeast of the North Portal Operations Area to supply water for repository activities for both operating modes. These wells have supplied water for site characterization activities. DOE would seek the necessary authorization to continue withdrawing water from the wells for repository activities. Alternative water sources could include supplying water via truck and pipeline.

Water would be pumped to a booster pump station, then to storage tanks at the North Portal Operations Area and the South Portal Development Area. These elevated tanks would provide gravity-fed water to the distribution systems. At both portal areas, water would go to potable and nonpotable water systems; the nonpotable systems would provide water to fire protection systems, to the supplemental system that would supply deionized water to the fuel storage pools, and to the cooling tower for the heating, ventilation, and air conditioning system.

2.1.2.1.4.6 Fossil Fuel. Fuel supply systems would include fuel oil for a central heating (hot water) plant, which would consist of a main tank and a day tank. In addition, there would be fuel supply systems for fire water system tank heaters, for diesel-powered standby generators and air compressors, and for

backup fire pumps. There would also be diesel fuel and gasoline to fuel vehicles during the construction, operation and monitoring, and closure of the repository. In addition, fossil-fuel powered vehicles would maintain the excavated rock storage area.

2.1.2.2 Repository Subsurface Facilities and Operations

DOE would construct the subsurface facilities of the repository and emplace the waste packages above the water table in a mass of volcanic rock (referred to as the *repository block*) known as the Topopah Spring Formation, which consists of *welded tuff* (see Chapter 3, Section 3.1.3.1). The specific area in this formation where DOE would build the repository emplacement drifts would satisfy several criteria: (1) to be in select portions of the Topopah Spring Formation that have desirable properties, (2) to avoid major faults for reasons related to both hydrology and *seismic* hazards (see Section 3.1.3.2), (3) to be at least 200 meters (660 feet) below the surface (DIRS 154554-BSC 2001, Section 4.2.1.2.9, p. 29), and (4) to be at least 160 meters (530 feet) above the present-day water table (DIRS 154554-BSC 2001, Section 4.2.1.2.4 p. 28).

The flexible design would use part or all of the layout shown in Figure 2-13. The smallest area that DOE would use is the shaded area that corresponds to the higher-temperature repository operating mode. DOE would use the full area shown for some of the possible lower-temperature repository operating modes (DIRS 153849-DOE 2001, Section 2.1.5.1).

The higher-temperature operating mode would utilize the upper (primary) block of the repository, using 4.7 square kilometers (1,150 acres) (DIRS 153849-DOE 2001, Section 2.3.1.1) (see Figure 2-13) and would require seven emplacement and development ventilation shafts. The lower-temperature repository operating mode could require as many as 17 ventilation shafts (see Table 2-2).

2.1.2.2.1 Subsurface Facility Design and Construction

The subsurface design would incorporate most of the drifts developed during the site characterization activities. Other areas would be excavated during the repository construction phase. Excavated openings would include gently sloping access ramps to enable rail-based movement of construction and waste package handling vehicles between the surface and subsurface, subsurface main drifts to enable the movement of construction and waste package handling vehicles, emplacement drifts for the placement of waste packages, exhaust mains to transfer air in the subsurface area, and ventilation shafts to transfer air between the surface and the subsurface. There would also be performance confirmation (observation) drifts for the placement of instrumentation to monitor emplaced waste packages (see Figure 2-13).

Access ramps connecting the surface and subsurface would be concrete-lined, 7.6-meter (25-foot)-diameter tunnels excavated by electric-powered tunnel boring machines (see Figure 2-14). Rail lines and an overhead trolley system would enable the movement of electric-powered construction and waste package handling vehicles. DOE developed the North and South Ramps, which would become part of the proposed repository, during site characterization. The North Ramp begins at the North Portal Operations Area on the surface (see Section 2.1.2.1.1) and extends through the subsurface to the edge of the repository area. It would support waste package emplacement operations. The South Ramp originates at the South Portal Development Area on the surface (see Section 2.1.2.1.2) and extends through the subsurface to the edge of the repository area. It would support subsurface construction and development activities.

The main drifts for the higher-temperature repository operating mode would include the East Main, the West Main, and the North Main. These drifts would be extended for the lower-temperature operating modes and additional main drifts would be excavated to provide access to other emplacement areas.